Experimental validation of the CAD-based co-simulation model of a linear track positioning system

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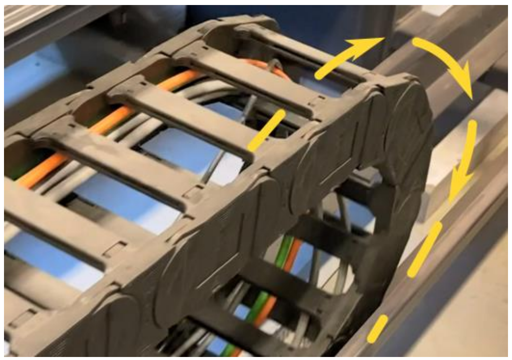
Goal

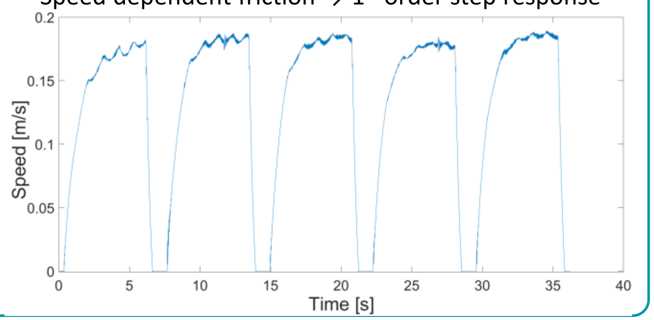
The goal of the SBO Work-Drive project is to achieve a collaborative and adaptive control of a modular mechatronic system such as a linear track setup with a 6DOF robot arm. To achieve this, precise knowledge of the system's behaviour is needed. The bottom platform of the linear track at UGhent, campus Kortrijk, exhibits friction and an oscillatory resisting torque. The goal is to model these two effects in a CAD-based co-simulation.

Motivation

- Accurate knowledge of system and model to:
  - Develop the control in a simulation environment
  - Implement disturbance compensation and adaptive control
- Vertical up and down motion as cable guide (un)folds → Wavelike resisting torque at low speeds

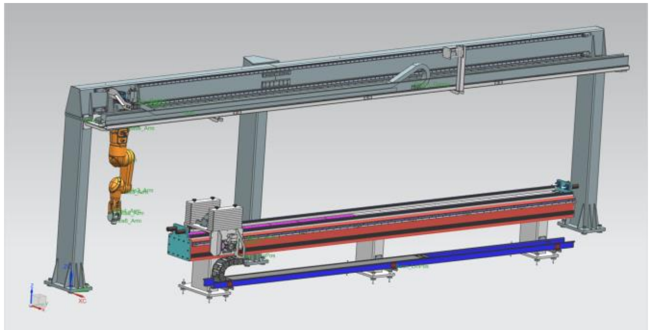


- Speed dependent friction → 1st order step response



Approach

- Co-simulation between a CAD model in Siemens NX (which provides the motion simulation) and Matlab Simulink (which provides the torque inputs)



Proposed model:

- Friction and cable guide movement are modelled by a position (x) dependent load torque $T_f(x)$
- A, B & C are the factors applied to each term of $T_f(x)$
- D determines the wavelength of the sinusoidal motion
- e^{Ex} is an exponential decay term, which attenuates the sinusoidal motion as the cable guide folds

$$T_f(x) = A\frac{dx}{dt} + Bx + C\sin(Dx)e^{Ex}$$

Parameter identification:

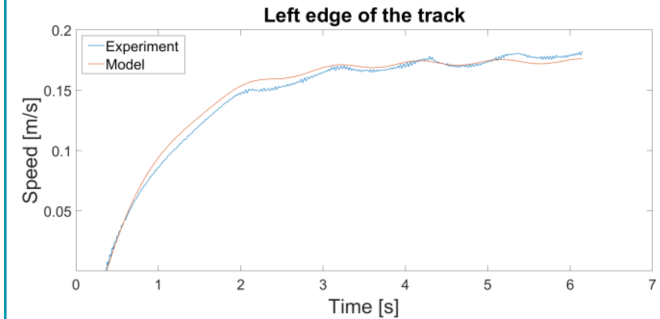
- fminsearch for $T_f(x)$ parameters in Matlab
- Platform weight is adjusted in the CAD model to match the experimental time constant
- Data set of 5 steps → Covers the whole track
- Least squares cost criterion

Hypothesis and limitations:

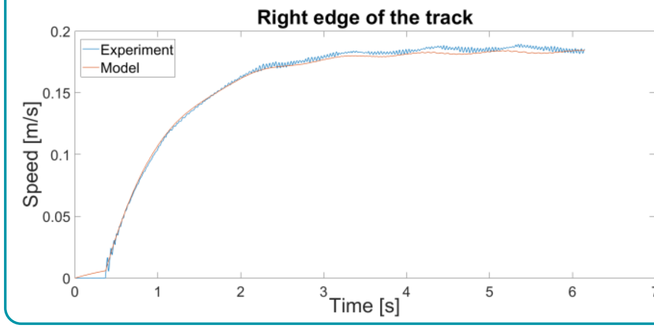
- Constant gearbox temperature
- Model valid only for small torque inputs
- Model valid only for a fixed platform weight

Results

- Results obtained through the optimization routine
- 1st order step response achieved with the right time constant and steady-state speed



- Sinusoidal effect decreases as the platform moves to the right



Key take-aways

- **Low-speed friction and cable guide motion successfully modelled as an influence on the platform's movement**
- **Further improvements are to apply these methods for all speed working points, different platform weights and model the influence of the gearbox's temperature**
- **Compare to data-driven model (Neural nets or non-linear ARX)**